

Waste Management

Life Cycle Assessments for Waste, Part I:

Overview, Methodology and Scoping Process

Strategic EIA for the Dutch National Hazardous Waste Management Plan 1997-2007

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Preamble

This series of three articles titled "LCAs for Waste" describes the experience of performing comparative assertions of hazardous waste management technologies for the second Dutch National Hazardous Waste Management Plan (NHWMP) 1997-2007. For this plan, Dutch legislation required that a strategic (thus: chain-oriented) Environmental Impact Assessment (EIA) had to be made. The NHWMP, which was written in parallel, used the EIA's results directly to establish so-called 'minimum standards'.

These can best be described as a 'Best available technology' for management of certain hazardous wastes. Only such tech-

nologies would be licensed under the NHWMP.

The first part describes the Dutch hazardous waste management structure, and the goal and scope definition step for the chain-oriented EIA.

The second part presents a comparison of thermal treatment technologies.

The third part provides a comparison of paint packaging separation plants. Furthermore, it gives a general review of the usefulness of LCA for the NHWMP, its acceptance in the public consultation phase, and the experience with the review process by the Dutch EIA commission.

Abstract

Part I (from three parts) of the series "LCAs for Waste" describes the Dutch hazardous waste management structure, and the goal and scope definition step for a chain-oriented Environmental Impact Assessment (EIA). For about 7 waste sectors, no change in existing policy was foreseen and Dutch legislation required no comparative assertion. For 7 others, a lack of inventory data or methodological problems did not allow for the performance of a meaningful quantitative LCA.

For the remaining 7 sectors, LCAs were performed to deal with 12 technology choices. They were based on primary data for the central processes, and literature data for background processes. A slightly adapted approach of the 1992 CML manual was used. System enlargement appeared to be slightly preferable as an allocation method.

Keywords: Dutch National Hazardous Waste Management Plan; EIA; Environmental Impact Assessment; hazardous waste; LCA; Life Cycle Assessment; scoping process; waste management; waste

Hence, the Dutch authorities came into the position that they had to make a so-called *strategic EIA* on the (second) National Hazardous Waste Management Plan (NHWMP) they wanted to launch in 1997 (VROM/IPO, 1997)¹.

LCA played a key role in this EIA (TUKKER, 1996a). Interesting features were that it had to be performed quickly and for a limited budget, that it was subject to an extensive public participation and review procedure, it dealt with decisions related to high financial stakes, and lead directly to input into the policy making process: The authorities wrote the draft NHWMP *in parallel* to the EIA – where often regular LCAs are completed and discussed for a considerable time before decision making as such comes into sight. We feel that several lessons can be learned from this case. These experiences will be reflected in a series of three articles, particularly aiming to give insight into aspects like:

¹ Usually, Strategic EIAs, Project EIAs and Location EIAs are discerned (cf. FELDMANN, 1998). Strategic EIAs deal with rather generic planning decisions, like made in a national electricity plan, a waste management plan, or a town planning plan. Project EIAs deal with the effects on the (local) environment and possible mitigating measures of a concrete project for e.g. an industrial plant or road. Location EIAs deal with the choice where a specific plant or a road can best be located. Political decisions taken on planning level inherently limit the freedom of choice of alternatives in individual projects and individual location choices. This explains the recent interest of the European Commission in strategic EIAs (EU, 1996), since only by including EIAs on this level, environmental aspects are taken into account in the full range of the decision making process.

1 Introduction

In 1994, the scope of the Dutch Decree on Environmental Impact Assessment (EIA) was considerably extended. EIAs became mandatory for virtually all hazardous waste treatment processes. This also included decisions on the planning level.

- What role can LCA play in strategic EIAs?
- What preferences can be indicated with regard to treatment options for selected hazardous waste streams?
- How can LCA be applied cost-effectively in such tense decision making processes, and what is the optimal approach to public participation?

2 The Dutch Hazardous Waste Management System

2.1 Technology structure

Figure 1 (p. 277) provides the object of the Dutch NHWMP: The total Dutch hazardous waste management structure. Over 20 waste groups can be distinguished which are treated by about 20 so-called 'sectors' of firms that perform more or less the same activities. The plan discerns the following sectors:

Sector 1: Small quantities of hazardous waste

Dutch legislation defines 'small quantities of hazardous waste' as hazardous waste produced in small amounts by households and SMEs. For such waste, a special collection system has been established consisting of specialised collection firms, civic amenity sites, etc. They sort, collect and accumulate the waste into bigger lots for treatment by other firms in the structure.

Sector 2: (Chlorinated and organic) solvents

Halogenated and non-halogenated solvents are accumulated via the collection system for small quantities of hazardous waste, and by a number of other specialised firms. Treatment options are distillation (resulting in a secondary solvent, and a residue that has to be incinerated), and incineration.

Sector 3: Waste oil

Also for waste oil, a specific collection structure exists. Most collectors also have a treatment installation. The water fraction is removed and discharged after treatment; sediments are removed by centrifugation and sent to incineration. The oily residue is suitable as a secondary fuel².

Sector 4: Oily sludges (o/w/s)

For mixtures of oil, water and sludge (o/w/s) generated by garages and similar workshops, a dedicated collection system has been set up. Several firms separate the o/w/s in oil (which is later treated by incineration or used to produce secondary fuel), water (that is discharged after purification) and sludge (which is usually incinerated). For other sludges, no dedicated collection structure has been set up. These sludges are partially treated by the above mentioned o/w/s pre-treatment plants, and partially treated by companies dealing with shipping waste.

Sector 5: Ship waste

For shipping waste, a specific collection structure exists. Shipping waste consists mainly of mixtures of oil and water or chemicals and water. It is treated by a small number of rather large companies that separate any present oil (which is mainly sent to incineration), water (which is purified and discharged),

and sludges (which are sent to incineration). These companies also treat a large part of the waste water flows that are either generated in tank cleaning operations or produced in processes that lack specialised waste water treatment.

Sector 6: Incineration (incinerable waste)

From almost all other sectors, residues are generated for which incineration is the only option. Furthermore, waste is generated from primary generators that can only be incinerated. Incineration options include: rotary kilns, municipal solid waste incinerators (MSWIs) and use as a secondary fuel, e.g. in cement kilns. Waste rich of organochlorine and organosulphur can be incinerated in dedicated kilns that produce hydrochloric acid or sulphuric acid as a by-product.

Sector 7: Paint and chemicals packaging

Spent packaging of paint and chemicals consists of packaging with hazardous residues such as paint, ink, and glues. Part of this waste flow is incinerated, but particularly packaging for paint can be treated in a separation plant. This results in a metal fraction (which can be re-used), a plastic fraction (for which incineration usually is the only option), and paint sludge (which requires incineration as hazardous waste).

Sector 8: Specific health care waste

For specific health care waste (blood bags, needles, infectious materials), a dedicated collection structure exists. For this waste, a specific incinerator is available in the Netherlands.

Sector 9: Photochemical waste

For photochemical waste, a dedicated collection structure exists. Treatment includes silver recovery by electrolysis, separation of other inorganic substances from the water fraction (e.g. by inversed osmosis and/or evaporation), and solidification of the resulting sludge.

Sector 10: Acid and alkalic liquid waste

Acid and alkalic liquid waste are generated in the process industry, and in the metal finishing industry. A large part can be re-used, but particularly if contamination with heavy metals is at stake, treatment is the main option. By physical-chemical treatment, metals are precipitated and concentrated in a filter cake. This is landfilled as hazardous waste, sometimes after immobilisation.

Sector 11, 12 and 13: (Inorganic) C1, C2 and C3-waste (landfill)

C1, C2 and C3-waste are waste types which in principle have to be landfilled. It concerns inorganic waste with a high metal content, such as the filter cake from physical-chemical treatment or fly ash from waste incineration. Leaching characteristics determine which category applies. C3-waste is moderately leachable, and may be landfilled on a controlled landfill. C2-waste is highly leachable, and can be landfilled if very stringent measures have been taken. C1-waste is a very small category that used to be landfilled in salt mines. Immobilisation is increasingly used as a pre-treatment of C2 and C3-waste.

Sector 14 to 20: Others

A number of other waste flows can be discerned, that more or less have a separate position in the structure:

- Blasting grit (14), which in part can be purified and re-used,

²Early 1999, quality standards for fuel were tightened in Holland. This implies a more sophisticated technology is necessary in the meanwhile, which should include a dechlorination step in order to remove chlorinated impurities in the oil.

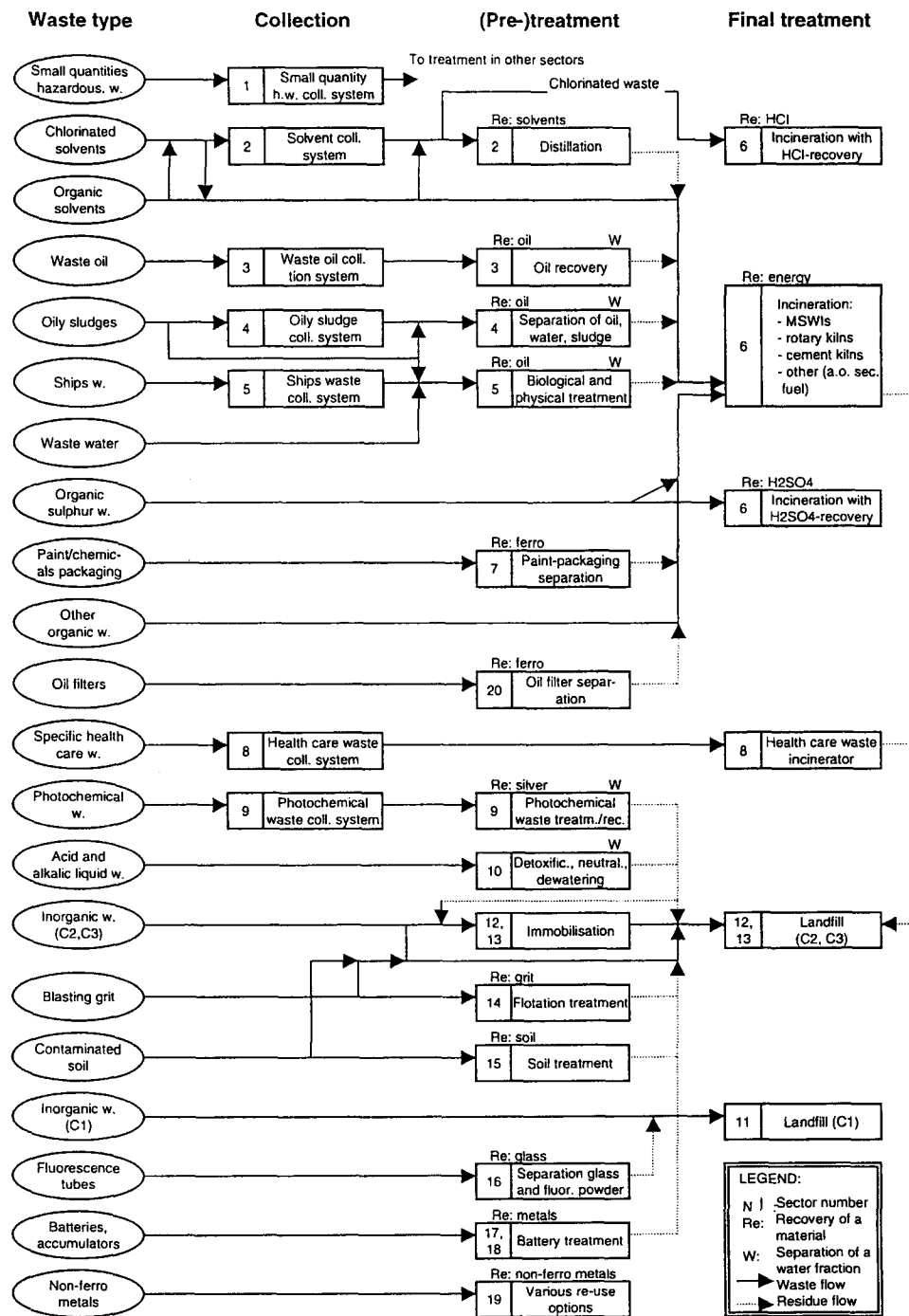


Fig.1: An overview of the Dutch hazardous waste management structure

- and in part has to be landfilled as C3-waste;
- contaminated soil (15) that can be treated by various technologies. Residues from thermal technologies in general have to be landfilled as C2 or C3-waste;
- fluorescence tubes (16), which can be separated in glass (for re-use) and fluorescence powder, which is C1-waste and needs further treatment;
- small batteries (17), for which various treatment options

according to battery type exist;

- accumulators (18), mainly from cars, which can be treated in a mechanical separation process for lead recovery;
- non-ferro metals (19), which are mainly re-used;
- oil filters (20), mainly from cars which can be treated by mechanical separation, resulting in re-usable scrap iron and a residue that has to be incinerated.

The figure shows that the structure has evolved into a system with a lot of tailor made technologies for specific waste streams. Many technologies result in residual fractions that can be re-used (in the figure indicated with 're:') or separate a water fraction that is discharged (indicated with 'w'). Also, various technologies lead to hazardous waste residues that have to be treated with another technology in the system.

2.2 Planning system

In the Netherlands, the system described in Figure 1 is mainly in the hand of the private sector. However, market access is strictly regulated by a permit system which is based on criteria laid down in the NHWMP. This market control takes place in two ways:

- Imports and exports of hazardous waste for final treatment are regulated by a licensing system controlled by the central government, based on the EU Directive on the transboundary movement of waste;
- in order to collect or to treat waste, a license is needed from the provincial government. This license includes not only the local, environmental aspects (as for any industrial plant), but also criteria based on the notion of 'suitability'. Suitability is a term based in the Dutch waste legislation and includes checks on aspects like a match of waste supply and processing capacity and the effectiveness and efficiency of treatment³. If establishing a new waste processing plant is not 'suitable', no license can be granted, even if all the normal environmental demands for industrial plants are met.

A key element of suitability is 'effectiveness and efficiency of treatment'. This criterion was further operationalised in 1995 when the notion of a 'minimum standard' was defined: that specific waste treatment process that could be regarded as a Best Available Technology (BAT) for a specific waste – not concerning local emissions, but rather for the full chain of treatment (VROM/IPO, 1995a)⁴. The 1997 NHWMP should list for each sector a 'minimum standard'. It would be regarded as a reference for minimum environmental performance; only technologies that would perform equal or better could be granted a license. The authorities saw the obligation to write an EIA as an excellent opportunity to perform a consistent and transparent assessment of what should be the minimum standard/BAT for each waste type. The Dutch hazardous waste management permit system might therefore be one of the few examples where *environmental performance on system level* became a criterion in licensing a process technology - where usually only environmental impacts on the *direct surroundings* are relevant in licensing.

³In the last few years, EU jurisprudence showed that transboundary movement of waste for recycling should be free in the EU. Thus, since exports could not anymore be controlled, for recycling technologies capacity planning became impossible and was dropped in 1997. For some treatment technologies serving a national market provinces need an approval of the central government in the licensing process. Most probably hazardous waste licensing will be centralised in the near future.

⁴The first comprehensive NHWMP appeared in 1993, and before that time individual License policy documents were written for each sector whenever needed. These documents did not yet use a common, transparent method for comparing waste treatment methods (VROM/IPO, 1993; NVCA, 1992).

3 Goal and Scope Definition of the EIA

3.1 Introduction

The Dutch EIA process is highly regulated. An EIA should elaborate and compare environmental friendly alternatives for the proposed plan or project. By writing an EIA in parallel to the development process of a plan or project, an interaction is envisaged. Those involved in planning or project development may be triggered to adjust their proposals by the insights about environmentally friendly alternatives developed in the EIA.

For any EIA, the party responsible for the initiative subject to decision making (here: the NHWMP) has to provide an Announcing document. In this document, provisional choices about the scope and approach in the EIA are given (VROM/IPO, 1995a). The document is public, and any interested party can provide a written reaction to it. Furthermore, a working group of experts, appointed by an independent Dutch EIA Commission, writes advice for the Terms of Reference (ToR) of the EIA. On this basis, the authority who is finally responsible for decision making writes a formal ToR. Then, on behalf of the initiator, the EIA is written (and in this case: the proposed NHWMP as well), which is in turn subject to public participation and review of the expert group of EIA Commission⁵. The request of the initiator and the EIA is provided to the authority which then takes its decision.

Usually, during the initial stage of writing an EIA the practitioner and the initiator have to specify many of the choices made in the ToR. In this section, the choices made in this formal and informal process are presented and discussed. It concerns:

- The choice of the sectors subject to EIA;
- the choice of the environmental evaluation tool applied;
- choices with regard to the LCA methodology for sectors subject to LCA;
- choices with regard to public participation and peer review.

3.2 Choice of the number of waste sectors included

For the 1997-2007 plan, a full EIA had to be made for the first time. Ideally, we would have performed an emission inventory combined with Life-cycle Impact Assessment (LCIA) for the whole hazardous waste treatment system in Figure 1, including illegal dumping and other losses. An improvement analysis on the priorities thus revealed would have indicated which measures would have the highest pay-off: investment in alternative, new technologies, end-of pipe treatment to deal with one specific emission, or even investment in additional enforcement⁶.

However, this ideal was too ambitious. The authorities faced considerable financial and time constraints. The whole

⁵Formally, the review is an advice of the EIA Commission to the authorities which in principle can be neglected. Normally, however, a strongly negative advice will lead to improvements or additions to the EIA, which have to be reviewed again.

⁶We used this approach successfully in the Dutch chlorine- and the Swedish PVC-chain study and later in our work for the first Irish NHWMP (TUKKER et al., 1995; 1996b; 1997 and 1998a; KLEIJN et al., 1997; TES, 1998).

project had to be concluded in only 6 months and stringent priorities had to be set⁷. The Dutch EIA decree only demands an EIA for 'new' decisions. Sectors where no policy changes were foreseen or necessary, in comparison to the old NHWMP of 1993, in principle required no attention in the EIA. On this basis, the authorities concentrated the EIA on about 14 sectors (→ Table 1, p. 280).

3.3 Choice of the method of comparison

For the selected sectors, the authorities wanted to identify a 'minimum standard'. As explained above, this requires insight in the (potential) impacts related to different waste management *chains* (which could be assessed with LCA), rather than a prediction of actual impacts of technologies on a local level (usually analysed with risk assessment). The latter type of analysis is rather irrelevant for the strategic, location-independent choices made in the NHWMP, and normally takes place in the project-EIA of a firm that wants to establish a treatment plant on a concrete location.

The Announcing document and the EIA Commission's expert advice on the ToR were rather unspecific about the method to be used (EIA, 1995; VROM/IPO, 1995a and 1995b). A 'qualitative judgement on the basis of quantitative data' was asked for as a minimum. The authorities and the experts of the EIA commission were afraid that full LCAs would lead to unacceptable time frames and budget needs. At the same time, it was clear that the quality demands made by stakeholders in the outside world would be high. The authorities wanted to translate the results of the EIA directly into licensing guidelines in the NHWMP, and thus could expect protest of companies who would be negatively affected. This implied that the results of the EIA in extreme cases should be able to survive discussions in the Court of Appeal.

During the first (inventory) phase of the EIA, it appeared that rough emission profiles could be rather easily obtained for most technologies. At that moment, TNO decided to perform LCAs where feasible after all, particularly for the sectors in the upper half of Figure 1 (mainly streams that finally end up in incinerators). We were only reluctant to do so for sectors in the lower part of Figure 1. For most of these sectors, landfill plays a dominant role. Important environmental problems related to landfill are human and ecotoxicological effects caused by losses of leached heavy metals through the liner- and leachate treatment system⁸. It was clear from the start that the uncertainties in leaching behaviour (e.g. FINNVEDEN et al., 1995) and LCIA of toxic releases would be large. Even with major additional money and time budgets, quantitative LCA would merely give an unjustified sense of quality. Therefore, in these 5 sectors we stuck to a qualitative, mainly argumentative evaluation (see Table 1). We will not discuss this qualitative approach further here. For 2 sectors, generally accepted comparisons had already been performed, which simply could be summarised in the

EIA. As indicated in Table 1 (p. 280), LCA was finally applied in 7 sectors, covering about 12 technology choices.

3.4 Choices with regard to the application of LCA

At the time of the start of the project, the 1992 CML manual was the most commonly applied in the Netherlands. Therefore, this manual was used as a basis (HEIJUNGS et al., 1992)⁹.

The *goal and scope* aspects mainly concentrated on the question of which alternative technologies had to be included. In general, it was clear which the available mainstream technologies were and selection of the alternatives was straightforward. It has to be stressed that the EIA did not aim to include any thinkable option, nor to select a single allowed technology. The EIA merely had to identify a proven and much used technology as an environmental reference – after all, a minimum standard should be capable of unproblematic treatment of current waste flows. Suppliers of a new technology are free to make a comparison with the minimum standard, and obtain a licence if it performs equal or better in environmental terms.

The *functional unit* was always the treatment of 1 tonne of a waste with a specific composition. If relevant for the sector at stake, a range of typical compositions was taken into account. As we will make clear in Part II, we considered allocation on the basis of system enlargement slightly preferable for waste management technologies with multiple functions.

As for the *inventory*, in general rather acceptable inventory tables could be made for the central waste treatment processes making use of data available in the project-EIA of the firms, their license applications or other readily available material. With a targeted inquiry to the firms at stake in most cases, relevant missing items could be included as well. For the secondary (background) processes, we relied on commonly used databases such as ETH, Buwal and earlier Dutch LCAs on waste (AOO, 1995; SAS, 1994; FRISCHKNECHT, 1994). Capital goods were excluded.

As for *impact assessment*, the CML-guide was followed. We skipped environmental themes with a purely local character (odour, noise), which are still poorly operationalised (resource use, land use), and some rarely applied themes like radiation and waste heat. We added primary energy use and the amount of final waste to cover resource use and land use to some extent. We deliberately excluded terrestrial ecotoxicity. This theme was totally determined by leaching of metals to soil in our comparisons. However, it is virtually unknown in which case leaching is worse on the long term: From metals ending up in waste that is landfilled, or from waste that is immobilised and re-used, etc¹⁰. Scores would merely have reflected

⁷This schedule was not totally met; a draft EIA suitable for a first review by the expert panel of the EIA commission was completed in about 7.5 months.

⁸Note that in the Netherlands only inorganic hazardous waste may be landfilled.

⁹The new manual for impact assessment of toxic releases (GUINÉE et al., 1996) became available only during the project. It has to be noted that the LCAs were performed well before the time that the ISO 14040 series on LCA was published as (draft) standard. Some of the choices we made are not in line with these standards, for instance the fact that we applied a weighting step in what actually is a comparative assertion disclosed to public. Personally, I feel there are good reasons for the choices presented in this section.

¹⁰We did include leaching of metals to soil in the inventory making use of some very rough assumptions of AOO (1995). But in impact assessment, we only included them in themes where they would not dominate the scores (i.e. human toxicity).

unfounded theoretical assumptions (cf. FINNVEDEN et al., 1995; TUKKER and WRISBERG, 1998). For normalisation, we used Dutch totals derived by Tukker et al. (1995)¹¹. Since it is virtually impossible to communicate tables and graphs with about 10 theme scores, we used 3 weighting methods to give a more reduced amount of scores by technology in a graph. We clearly warned the figures could not be used out of their context and that the (of course much more outbalanced) text should be the reference for conclusions. The weighting sets used were: A Distance-to-target (DtT) set derived from Dutch policy goals in 2000 (see also TUKKER et al., 1995), equal weights for all themes, and a DtT set with a zero weight for landfill volume. The latter set was included since mine tailings dominated landfill in several comparisons, but the waste character of this material is sometimes debated.

3.5 Public participation and peer review

As already reflected by section 3.1, the Dutch EIA legislation makes minimum demands to public participation and peer review.

In short, stakeholders have the right to comment on the Announcing document, thereby having influence on the scoping process. Furthermore, they have the right to comment on the EIA (and the simultaneously published proposed decision, here the proposed plan). Stakeholder involvement above this legal minimum was deliberately rejected¹². This was partially a reaction on the experience with the process of the first NHWMP of 1993. Then, much initiative had been given to the representative organisation of waste treatment firms. They would write the proposed plan within a framework set by the authorities (NVCA, 1992). But this had lead only to delay tactics, conflicts *during* writing the plan, and not to consensus *over* the plan. In the end, the authorities still had to make the hard decisions themselves (VROM/IPO, 1993). Since, as I stressed earlier, the inclusion of stakeholder views in LCA is highly relevant, we used an alternative for stakeholder participation (TUKKER, 1998b). Over the years we had done many projects in the hazardous waste field, leading to a rather good idea about stakeholder views. Literature analysis could further help to fill out gaps in our insight. Where we felt unsure, we organised an informal meeting with a stakeholder - in most cases not about project results, but to talk about their concerns concerning a specific subject. In this way, we tried to include all relevant views when making the EIA.

Peer review is embedded in the procedure required by the Dutch EIA legislation. The same expert panel that commented on the Announcing document, would later have to check to see if

the final EIA would meet the criteria in the ToR and have a reasonable quality in general. Interactive peer-review is not foreseen in the Dutch EIA regulations. In fact, the Dutch EIA Commission feels very reluctant to accept demands for intermediate judgements, mainly since they are concerned with maintaining their independent review role.

4 Conclusions

Table 1 summarises the results of the goal and scoping process for the EIA. Out of the 20 sectors of which the Dutch hazardous waste management system consists, no new decisions have to be taken for 7 in comparison with the policy laid down in the NHWMP of 1993. Therefore, they are not treated in the EIA. For 5 sectors, landfill plays a dominant role. The expectation was that LCA would only give a false sense of accuracy and a qualitative/argumentative analysis was preferred. For 2 other sectors, existing and generally accepted evaluations could be summarised in the EIA. In 7 sectors, covering 12 technology choices, quantitative LCA would be used to select a minimum standard.

In follow-up articles, the approach and results are discussed further. As an illustration, two technology choices will be

Table 1: Result of the goal and scoping process of the EIA

Sector	Comparison	Approach
1: Small quantities of hazardous waste	-	-
2: (Chlorinated and organic) solvents	a. treatment of halogen-free solvents	LCA
3: Waste oil	-	-
4: Oily sludges (o/w/s)	a. treatment of the oil fraction b. treatment of the sludge fraction c. treatment of drilling oil	LCA LCA LCA
5: Ship waste	a. treatment of the oil fraction	LCA, see o/w/s
6: Incineration	a. comparison of incineration alternatives	LCA
7: Paint and chemical packaging	a. treatment of paint sludge b. separation of paint and packaging c. treatment of plastic packaging with paint	LCA LCA LCA
8: Specific health care waste	-	-
9: Photochemical waste	a. treatment of paper and film b. treatment of photochemicals	matrix LCA matrix LCA
10: Acid and alkalic liquid waste	a. treatment of pickling solution	*
11: C1-waste	a. treatment of C-1 waste	qualitative
12: C2-waste	a. treatment of C-2 waste	qualitative
13: C3-waste	a. treatment of C-3 waste	qualitative
14: Blasting grit	a. treatment of blasting grit	qualitative
15: Contaminated soil	-	-
16: Fluorescence tubes	a. treatment of mercury residues	qualitative
17: Small batteries	a. treatment of small batteries	*
18: Accumulators	-	-
19: Non-ferro metals	-	-
20: Car oil filters	a. treatment of oil filters	LCA

-: no new decisions, thus not subject to EIA

*: the results of existing mainly qualitative comparisons already performed for the client were summarised in the EIA

¹¹ There, TNO and CML updated the normalisation values published by Guinée (1993). Just when we finalised the EIA, IVAM, Utrecht University and Pré Consultants published on behalf of the Ministries of Environment and Traffic, Public Works and Water Management the normalisation values which are currently most used in the Netherlands (RIZA/VROM, 1997). We were not anymore in the position to include these values in our work.

¹² Of course the Ministry and Provinces, as clients, were involved. Each hazardous waste sector was commented by some 5 officials, leading to a steering apparatus for the project of some 50 persons.

discussed in more detail. The first one addresses incinerable waste. Here the choice between hazardous waste incineration in rotary kilns, cement kilns and MSWIs was one of the most tense decisions that had to be taken in the NHWMP. The second addresses the best separation technology for paint packaging. Here, unexpected results followed which were perceived as being very threatening by companies who had just invested in the deemed technology.

4 References

- AfvalOverlegOrgaan (AOO, 1995): Milieu-effectrapport Tienjarenprogramma Afvalstoffen 1995-2005 [*EIA Ten-year Programme Waste Management 1995-2005*]
- EIA (1995): Richtlijnadvies Milieu-effectrapport Meerjarenplan Gevaarlijke Afvalstoffen 1996-2006 [*Advice for the ToR for the EIA on the Multi-year Plan Hazardous Waste 1996-2006*]. EIA Commission, Utrecht, the Netherlands
- EU (1996): Proposal for a Council Directive on the assessment of the effects of certain plans and programmes on the environment. COM/96/511 Final, Official Journal No. C 129, 25/04/1997, p. 14
- FELDMANN, L. (1998): The European Commission's Proposal for a Strategic Environmental Assessment Directive: Expanding the Scope of Environmental Impact Assessment in Europe. *Environmental Impact Asses. Rev.* Vol. 18, pp. 3-14
- FINNVEDEN, G.; ALBERTSSON, A.-C.; BERENDSON, J.; ERIKSON, E.; HÖGLUND, L.O.; KARLSSON, S.; SUNDQVIST, J.-O (1995): Solid waste treatment within the framework of life-cycle assessment. *J. Cleaner Prod.* Vol. 3, No. 4, pp. 189-199, Elsevier
- FRISCHNECHT, R. (ed.) (1994): *Oekoinventare für Energiesysteme*. ETH/PSI Villingen, ENET, Bern, Switzerland
- GUINÉE, J.B. (1993), Data for the Normalisation Step within Life cycle Assessment of Products. CML Paper 14, Leiden, the Netherlands
- GUINÉE, J.B.; HEIJUNGS, R.; VAN OERS, L.; V.D. MEENT, D.; VERMEIRE, T.; RIKKEN, M. (1996a): LCA Impact assessment of toxic releases. CML/RIVM, Product policy series 1996/21, Ministry for the Environment, The Hague, Holland
- HEIJUNGS, R.; GUINÉE, J.B.; HUPPES, G.; LANKREIJER, R.M.; UDO DE HAES, H.A.; WEGENER SLEESWIJK, A.; ANSEMS, A.A.M.; EGGELS, P.G.; VAN DUIN, R.; DE GOEDE, H.P. (1992): Environmental Life-cycle Assessment of Products. Guide and backgrounds. CML/TNO/B&G, Leiden, Holland
- KLEIJN, R.; TUKKER, A.; V.D. VOET, E. (1997): Chlorine in the Netherlands, Part I: An overview. *Journal of Industrial Ecology* Vol. 1, No. 1
- NVCA (1992): Visie van de NVCA op het Meerjarenplan chemisch afval 1992-2002 [*View of the Dutch Union of Hazardous waste management Firms on the Multi-year Plan on Hazardous Waste 1992-2002*]. NVCA, Schelluinen, the Netherlands. Written by a project team consisting of: A. Nijdam, J.C.J. van den Assem, J.B. Groen-Boom, A.C.P. Nijdam, A.C. Schravendeel, M. Tels, and A. Tukker
- RIZA/VROM (1997): Drie referentieniveaus voor normalisatie in LCA [*Three reference levels for normalisation in LCA*]. RIZA and the Ministry of Environment, Lelystad, the Netherlands
- SAS, H.J.W. (ed., 1994): Verwijdering van huishoudelijk kunststofafval: analyse van milieu-effecten en kosten [*Disposal of municipal plastic waste: analysis of environmental effects and costs*]. CE, Delft, the Netherlands
- TES (1998): Tobin Environmental Services, Clean Technology Centre Cork, and TNO. Strategy study for the first Irish National Hazardous Waste Management Plan, draft July 1998 (to be published)
- TUKKER, A.; KLEIJN, R.; V.D. VOET, E.; ALKEMADE, M.; BROUWER, J.; DE GROOT, H.; DE KONING, J.; PULLES, T.; SMEETS, E.; VAN DER STEHEN, J.J.D. (1995): A chlorine balance for the Netherlands. Report 95/40, TNO-STB and CML, Apeldoorn, Holland
- TUKKER, A. (ed., 1996a): Milieu-effectrapport Meerjarenplan Gevaarlijke Afvalstoffen 1997-2007 [*Environmental Impact Assessment Multi-year Hazardous Waste Management Plan 1997-2007*]. Ministry of Housing, Physical Planning and Environment and the Inter-Provincial Union, the Hague, the Netherlands
- TUKKER, A.; KLEIJN, R.; VAN OERS, L.; SMEETS, E. (1996b): A PVC substance flow analysis for Sweden. TNO-STB and CML, Report 96/48, Apeldoorn, Holland
- TUKKER, A.; KLEIJN, R.; V.D. VOET, E.; SMEETS, E. (1997): Chlorine in the Netherlands, Part II: Risk management in uncertainty. *Journal of Industrial Ecology* Vol. 1, No. 2
- TUKKER, A.; KLEIJN, R.; VAN OERS, L.; SMEETS, E. (1998a): Combining SFA and LCA: The Swedish PVC Analysis. *Journal of Industrial Ecology* Vol. 1, No. 4
- TUKKER, A. (1998b): Life Cycle Impact Assessment of Toxic Releases. Practical Experiences – Arguments for a Reductionistic Approach? *Int. J. of LCA* Vol. 3, No. 5
- TUKKER, A.; WRISBERG, N. (1998): Peer review LCA AVI-vliegias [*Peer review LCA Municipal Solid Waste Incinerator fly ash*]. Report 98/64, TNO-STB and CML, Delft, the Netherlands
- VROM/IPO (1993): Meerjarenplan verwijdering gevaarlijke afvalstoffen 1993-2003 [*Multi-year plan treatment hazardous waste 1993-2003*]. Ministry of Environment and the Interprovincial Union, the Hague, the Netherlands
- VROM/IPO (1995a): Startnotitie Milieu-effectrapport Meerjarenplan gevaarlijke afvalstoffen 1996-2006 [*Announcing Document EIA Multi-year plan hazardous waste 1996-2006*]. Ministry of Environment and the Interprovincial Union, the Hague, the Netherlands¹³
- VROM/IPO (1995b): Richtlijnen Milieu-effectrapport Meerjarenplan gevaarlijke afvalstoffen 1996-2006 [*Terms of Reference EIA Multi-year plan hazardous waste 1996-2006*]. Ministry of Environment and the Interprovincial Union, the Hague, the Netherlands
- VROM/IPO (1997): Meerjarenplan gevaarlijke afvalstoffen 1997-2007 [*Multi-year plan hazardous waste 1997-2007*]. Ministry of Environment and the Interprovincial Union, the Hague, the Netherlands

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¹³ During the course of writing the NHWMP, it was decided to make revisions every 4 year instead of every 3 year. Hence, at the start of the project the aim was to publish the NHWMP in 1996, where finally it was published in 1997.